

BBC



ARE EARTH'S POLES ABOUT TO FLIP?

...and what will happen to humanity when they do?



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SCIENCE AND TECHNOLOGY

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ISSUE 273 / OCTOBER 2014 / £4.25

YOUR LIFE IN...



To space
by balloon

Your cheap(ish) ticket
to heavenly views

Why stress is
good for you

Electric cars

Expert reviews to
help you ditch petrol



HOW X-RAYS WORK

The incredible story
of how we came to see
through the human body



Q&A

- How long can you stay awake?
- Can a bowl of rice dry a wet mobile phone?
- What happened to cold fusion?

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WELCOME



BEING THE EDITOR of *Focus* is a fantastic job, but it can be stressful sometimes. I'm sure your life can get stressful, too. But never has it occurred to me that, in some circumstances, stress might actually be a good thing. Yet that's exactly what science tells us, as you'll find out from Lilian Anekwe's article on p51.

Today's scientific discoveries shape tomorrow's technology, which shapes the future. So what will the future be like to live in? We asked three science fiction writers to pick some key breakthroughs and

turn them into stories about the year 2054. Turn to p41 to find out what your life will be like in 40 years – at home, at work and in your leisure time.

One future trend we're looking forward to is space tourism – a luxury that starts to get more affordable if you go in a balloon rather than a rocket. Two companies plan to take passengers to the edge of space in the near future, as Sarah Cruddas finds out on p62.

Elsewhere in a packed issue we look at the science of X-rays (p94), ask what will happen if Earth's poles flip over (p79), discover how likely amazing coincidences really are (p56) and get behind the wheel of four electric cars (p90). Enjoy the issue,

Graham

Graham Southorn, Editor

PS Don't miss our November issue, on sale 16 October 2014



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THIS MONTH WE...



...took the BMW i8 for a spin around the Berkshire countryside. Find out how we got on in a future issue – or watch the video on our new YouTube playlist, The Future Car Show.

...spoke to US science writer Benedict Carey about his new book on the science of learning. Read highlights of the interview on p106, or listen to the complete chat on the *Focus* podcast.



...went to the IFA electronics show in Berlin to check out the latest smartphones, smartwatches, fitness gadgets and fridges... yes fridges. Find out how cool they were in coming issues.

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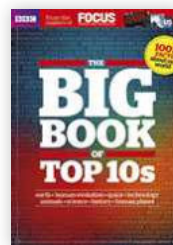
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APPEARING IN THIS ISSUE...



Sarah Cruddas

Sarah appears regularly on TV and radio to discuss all things space-related. In this issue, she looks at commercial efforts to give tourists the ultimate view of Earth (p62).



Timandra Harkness

Timandra, a full-time writer and humourist, loves finding the funny side of science. She was the perfect writer to investigate coincidences, and how unlikely they actually are (p56).



Kelly McGonigal

Stress makes you ill. Or does it? Health psychologist Kelly McGonigal believes stress can be a power for good, and tells us how to make best use of it (p51).



Frank Swain

Frank is the author of *How To Make A Zombie*. He joins Justin Pickard and Paul Graham Raven in imagining what life will be like in 2054, based on innovations today (p41).



WANT TO SUBSCRIBE?

Turn to p38 to **save 40%** on the shop price of *BBC Focus*



SUBSCRIBER BONUS

On p38, **Tom Heap** explains the latest advances and current hurdles in developing efficient wind power

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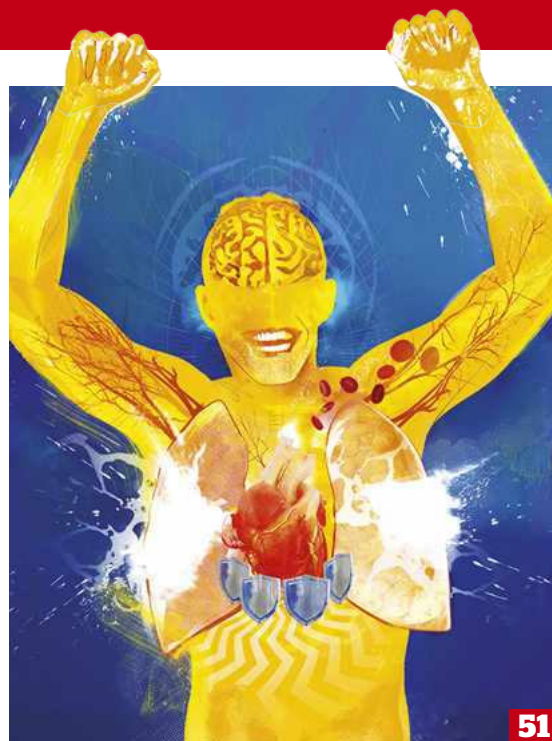
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Awe-inspiring images from the world of science

MegaPixel

Thumbs up for robots

WITH A DUSTBIN lid for a hat, a plastic beer barrel for a body and swimming floats for arms, this quirky character certainly stands out from the average traveller. Named hitchBOT, the intrepid wanderer has just completed a 6,000km hitchhike across Canada as part of a study into robot-human interactions led by Frauke Zeller and David Smith – assistant professors of communications at Canada's Ryerson and McMaster universities respectively.

"Usually, we are concerned with whether we can trust robots, but this project takes it the other way around and asks: can robots trust

human beings?" says Zeller. "We believe that through this we can learn a lot in terms of social robotics and how we approach robots in non-restricted, non-observed environments."

Unable to move under his own power, hitchBOT can wave his arm to attract kind passers-by, change the expression on his LED face according to his 'mood' and chat with drivers and other passengers – even if just to ask for permission to take a selfie. Find out how he made it from Halifax to Victoria at facebook.com/hitchBOT

PHOTO: CORBIS







+

MegaPixel

Mammoth find

MEET VIKA, A massive male steppe mammoth skeleton displayed at the opening ceremony of Serbia's Mammoth Park earlier this year. The remains were uncovered at Drmno coalmine, about 100km east of Belgrade, in 2009. Since then, seven more mammoths have been discovered in sites nearby.

"It's extraordinary to have this animal crouching, head upright, tusks pointing forward. It's just incredible to think this thing is at least half a million years old," says Prof Adrian Lister of London's Natural History Museum. "It must have died in shallow water and been rapidly covered over."

Steppe mammoths were an evolutionary predecessor of the better-known woolly mammoth, and much larger. Vika would have been about 4m tall and weighed nearly 10 tonnes, whereas "the woolly mammoth was no bigger than a modern elephant, sometimes even smaller," says Lister.

PHOTO: GETTY



MegaPixel

Cosmic cab

THIS IS THE future of manned spaceflight: SpaceX's Dragon V2. The vessel acts like a space taxi and will be used to deliver up to seven astronauts to the International Space Station, and Mars if SpaceX's CEO Elon Musk's plans come off. The plush interior was shown off in May, with a launchpad test due next month.

Dragon V2 will ride to space on a SpaceX rocket, but can then touch down almost anywhere on the planet with thrust from its eight boosters. It can land with the precision of a helicopter before being refuelled for another journey. This sets it apart from other crewed vehicles like Russia's Soyuz, which relies on a parachute to bring it down. "You can just reload and fly again," says Musk. "This is extremely important for revolutionising access to space because as long as we continue to throw away rockets and spacecraft, we will never truly have access to space."

PHOTO: SPACEX

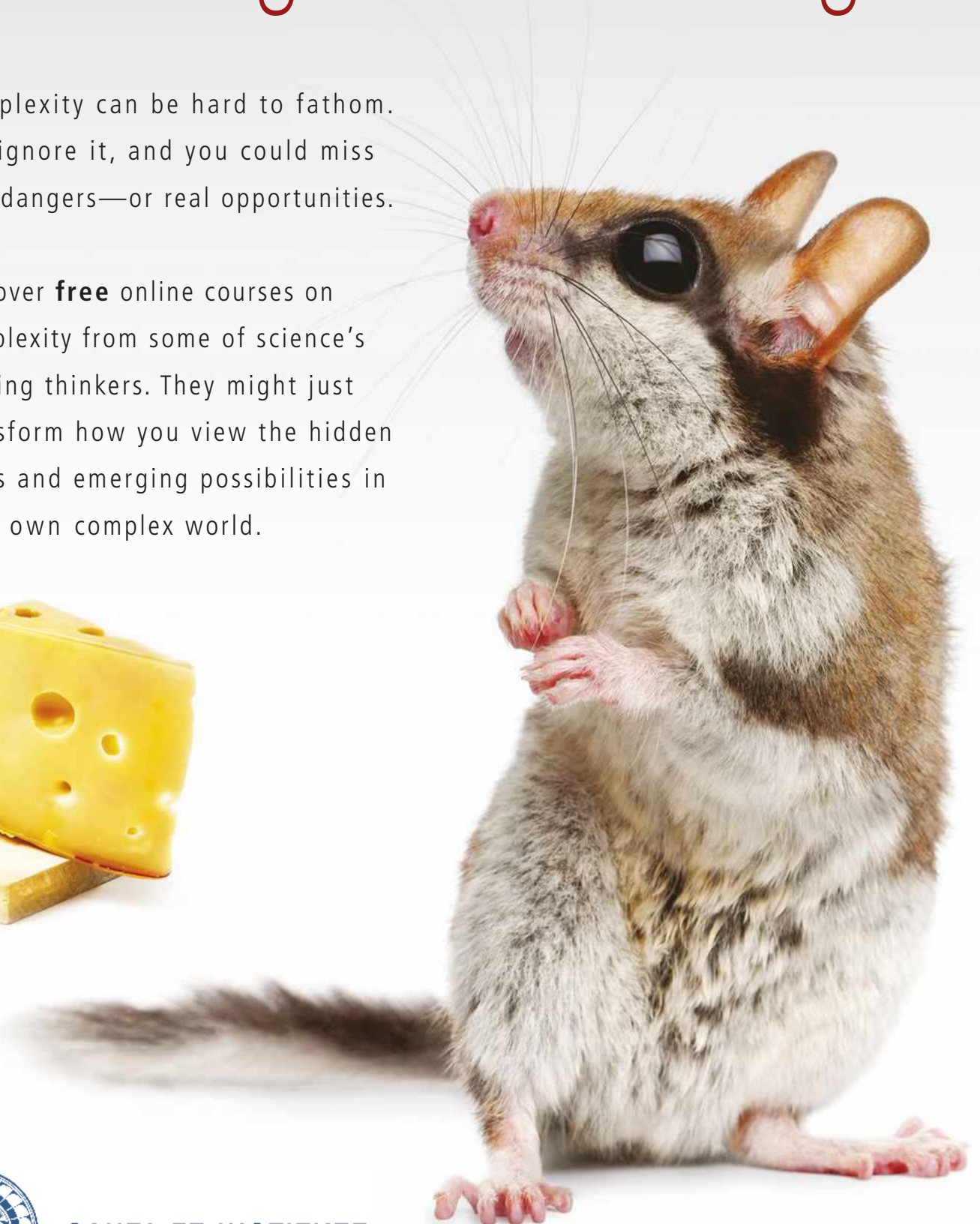
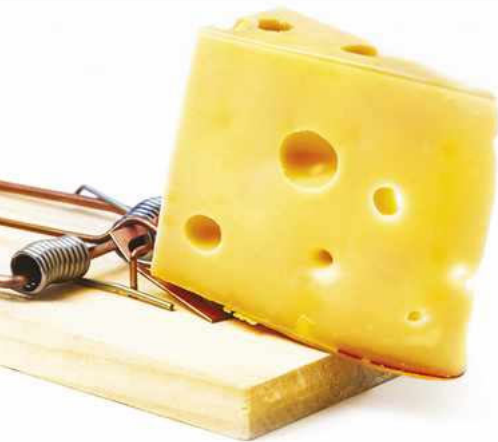


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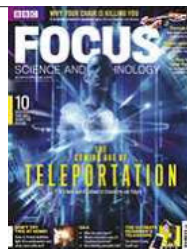


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MESSAGE OF THE MONTH



Human and animal waste can be a valuable source of methane gas, says Paul Jeffels

The new wind energy

Fracking (August, p23) has been badly handled in the USA and there are many reports of it resulting in environmental damage. The UK has a much higher population density than the USA, and thus the potential for problems is higher. Yet we have another source of gas that is readily available in the UK and simply requires the installation of more production plant. That source is biogas.

Anaerobic digestion of organic waste to produce methane has been around for more than 40 years, and there are many plants already in the UK (you can find details at biogas-info.co.uk). Anaerobic

digestion is free from environmental problems – in fact it gets rid of organic waste and turns it into useful gas.

Sewage is a case in point. There are roughly 60 million people in the UK, each producing approximately 500g of solid waste per day. That's 30,000 tonnes per day. Add to this animal slurry and waste from food processing and it adds up to a sizeable resource.

It would be a great thing if the British Government would put as much effort into exploiting biogas as it is currently putting into fracking.

Paul Jeffels, Derby

The power of dreams

In your interesting article about dreams (August, p37), you did not mention the most remarkable lucid dream. Paul McCartney woke up after dreaming the melody of *Yesterday*. He did not believe his creation was really his and tried hard to find evidence against his composership before claiming it as his own.

Philip D Welsby, Edinburgh

The article 'Take control of your dreams' (August, p37) by Rita Carter was enjoyable and insightful, but I can't help feeling that the ability to enter a lucid dream at will could have adverse affects. If we could enter into a lucid dream every night and control what we dream about, what would stop us from giving up on our goals in life if we could simply dream we'd achieved them instead?

Ben McGirr, Cardiff

It might work the other way round – people might be inspired to strive harder to match their dreams in real life. –Ed

In August's 'Q&A' (p70), Mark Adam asked, 'Can external sounds influence your dreams?' In the late '80s I awoke in the night and switched on my radio to drift off to sleep to the music. I then had a dream where a compère muted five words from five songs and these words had to be re-arranged into a recent film title. The answer was *The Secret Of My Success*. After waking up at the usual time, I listened to another few songs. After the second song the DJ said, "And now a repeat of the quiz." The quiz he then set was exactly the one that I had heard, and answered, in my dream! So dreams most definitely can be influenced by sounds.

Geoff Smith, Gretna

+ Write in and win!

The writer of next issue's Message of the Month wins a Samson Meteorite USB Microphone worth £47.99. The Meteorite is ideal for Skype, FaceTime and voice recognition tasks, as well as for recording music and capturing audio for podcasts and videos.

See www.samsontech.com



Greg Fairley says this €295 device works wonders for migraine sufferers

Stopping headaches

The article about headaches (Summer, p60) was very interesting. However, one of the most important and potentially successful treatments went unmentioned in your article – that of electric pulse therapy, and specifically the device produced by Cefaly (cefaly.com).

I recently purchased this device for my partner, who has been plagued with migraines since she was a teenager. She uses it every day and has not had a fully developed migraine in months. Further, on two occasions she used the device at the very beginning of the onset of a migraine and on both occasions her migraines failed to fully develop.

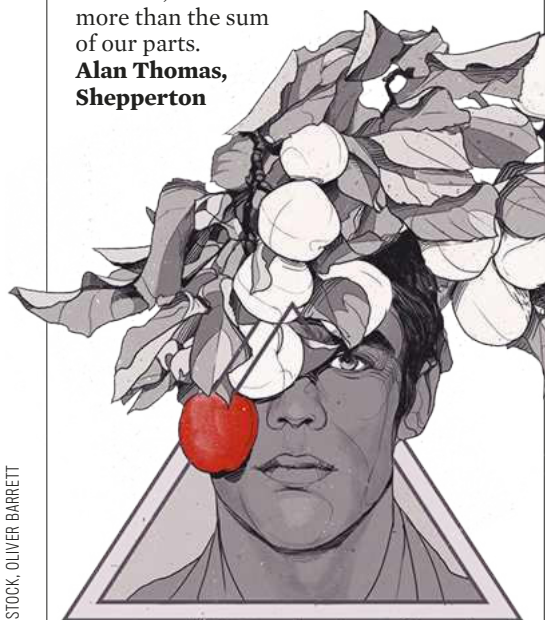
The device was recently approved by the US Food and Drug Administration, and you can rent it to see if it works for you. Just for the record, I am not connected in any way with Cefaly.

Greg Fairley

Hollywood brains

There seems to be a region of the brain for just about every action we take. 'Hollywood Science' (August, p114) introduced us to the posterior medial frontal cortex which, it seems, becomes involved when we change our mind in order to follow the crowd. Am I, and every action I take, to be explained by the functions of various brain regions? That gives a new twist to "I was only obeying orders"! Our brains have higher levels of function, and we are far more than the sum of our parts.

Alan Thomas, Shepperton



The film *The Giver* explores the idea of going against the grain. But can a brain region really explain why we do this?

Statin side effects

Robert Matthews (September, p31) dismisses the side effects of statins as simply 'muscular pain and tiredness' and concludes that they aren't even the result of statins – a statement that is debatable. The NHS Choices website has a fairly long list of known side effects, including muscle swelling and pain. Matthews also ignores research showing that statins can produce dementia-like symptoms. Preliminary analysis of research conducted by scientists at UCSD's Statin Study Group suggests statins can cause cognitive problems, including amnesia and disorientation. A further study published in July 2012 by the same group showed that statins do, in fact, cause fatigue.

Louise Morse, Cwmbran



YOUR COMMENTS ON OUR FORUM

The article on lucid dreaming in our August issue seems to have inspired a few *Focus* readers to try it out...

Thinker: I loved the lucid dreaming article. I've been keeping a diary of my dreams and actually managed to get into a lucid state. I used the trick of looking at my hands during the day and counting how many fingers I've got. The other night, while dreaming, I suddenly realised I had acquired three extra fingers in the form of clothes pegs. Once I had established that I was dreaming, I tried to take control, but it wasn't having it. But I'll keep trying.

M Paul Lloyd: I know what you mean with the problems over taking control of your dreams. The moment I try usually heralds the point when I wake up.

Join the discussion at
<http://sciencefocus.com/forum/>

Oops!

• On p100 of the August issue we incorrectly stated the height of One World Trade Center as 1,776m. It's actually 1,776 feet.

FOCUS

SCIENCE AND TECHNOLOGY

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DISCOVERIES

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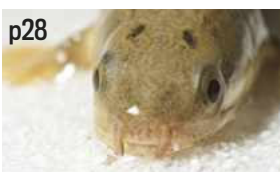


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EARS HOW HORSES TALK

It appears that horses have been secretly chatting with their ears

p28



FISH LEARN TO WALK

Scientists recreate the moment 400 million years ago when fish left the sea



p30

MARCH ON

Men find that walking in unison makes them feel more powerful

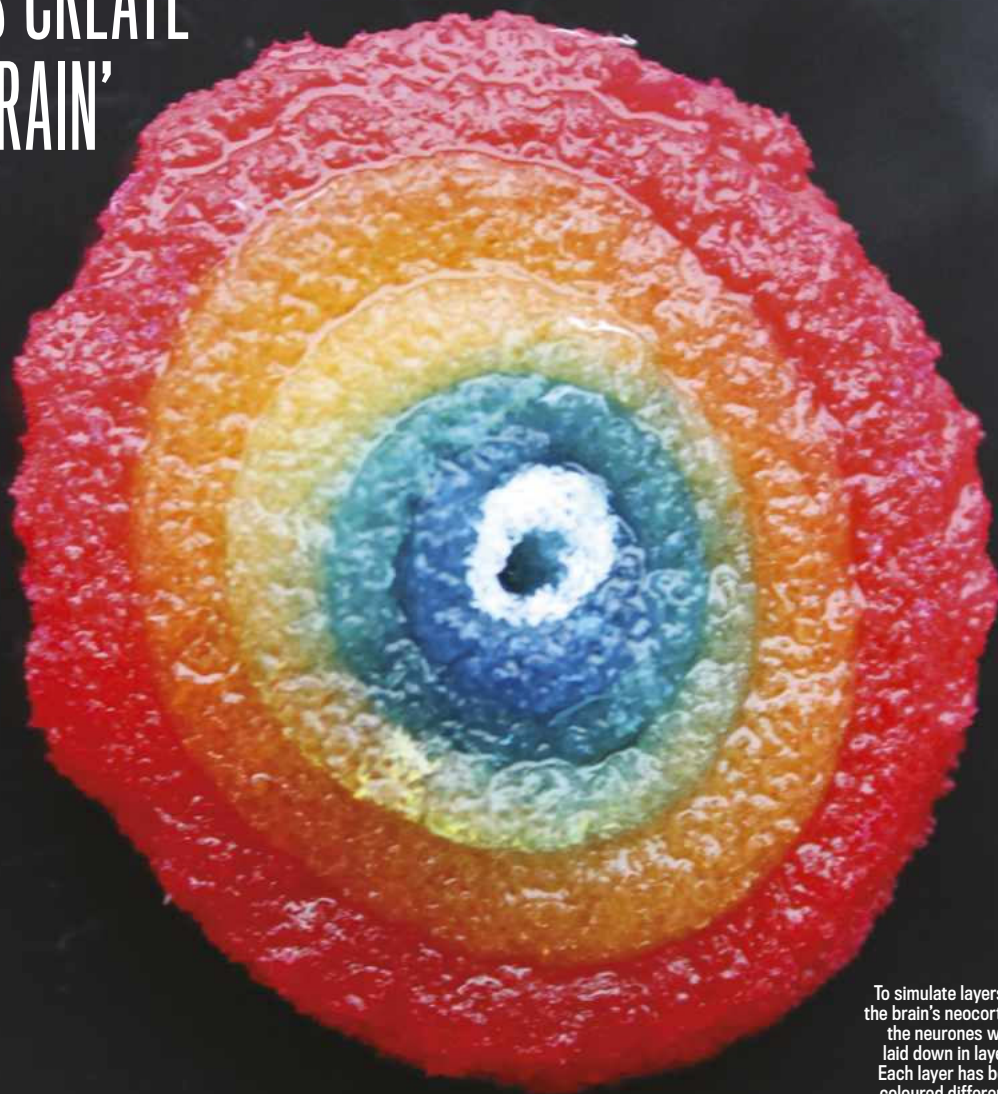
THE BIG STORY

BIOENGINEERS CREATE ARTIFICIAL 'BRAIN'

A groundbreaking method has enabled the study of complex, living brain tissue

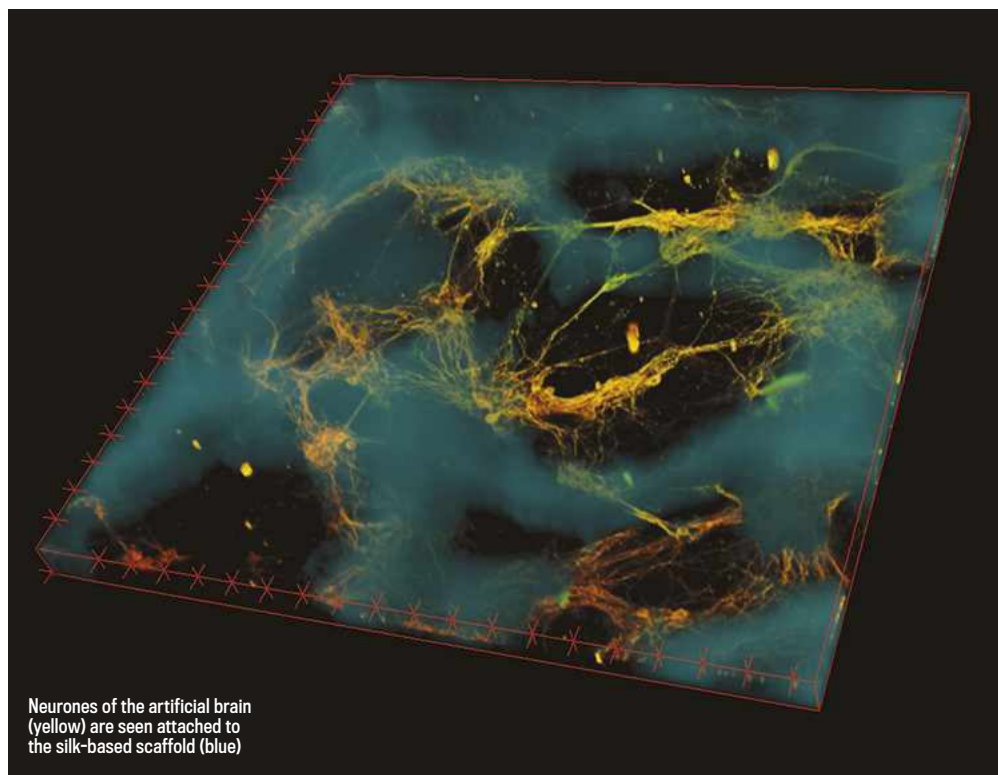
THE ULTIMATE science fiction B-movie conceit is a fully functioning brain in a jar. Now bioengineers at Tufts University, Boston, have brought the idea closer to reality after creating 3D brain-like tissue and keeping it alive for more than two months.

Until now researchers have grown neurones in Petri dishes for study. However, this method can only produce growth in



To simulate layers of the brain's neocortex, the neurones were laid down in layers. Each layer has been coloured differently with a dye

PHOTO: TUFTS UNIVERSITY



Neurons of the artificial brain (yellow) are seen attached to the silk-based scaffold (blue)

→ two dimensions and so is unable to replicate the complex structure of brain tissue. It includes segregated regions of grey matter, mainly neurones, and white matter, that is largely comprised of axons – projections neurones send out to connect with one another.

However, the brain tissue created at Tufts is 3D in nature and features grey-white matter segregation. “This work is an exceptional feat,” said Rosemarie Hunziker, Programme Director at the National Institute of Biomedical Imaging and Bioengineering. “It combines a deep understanding of brain physiology with a large and growing suite of bioengineering tools to create an environment that is both necessary and sufficient to mimic brain function.”

To make the tissue the researchers created a composite material from a spongy silk protein scaffold and a soft collagen-based gel. The scaffold served as a structure onto which neurones could anchor themselves, and the gel encouraged axons to grow through it.

They then populated this material with rat neurones that went on to form functional networks connected by axon projections in just a few days.

The researchers then dropped a weight onto the brain-like tissue from varying heights to study the effects of traumatic brain injury. The resulting changes in the neurones’ electrical and chemical activity proved similar to that seen in animal studies of traumatic brain injury. “With the system we have, you can essentially track the tissue response to traumatic brain injury in real-time,” said project leader David Kaplan. “Most importantly, you can also start to track repair and what happens over longer periods of time.

“The fact that we can maintain this tissue for months in the lab means we can start to look at neurological diseases in ways that you can’t otherwise. That’s because you need long timeframes to study some of the key brain diseases,” he added.

TIMELINE

A history of bioengineering

1997

Charles Vacanti grows a human ear shape on the back of a mouse using cow cartilage cells and a biodegradable mould.



2011

Paolo Macchiarini and a team successfully transplant a synthetic windpipe into a cancer patient using stem cells and 3D printing technology.

2012

Researchers from the University of Wisconsin grow functional ‘liver buds’ using human stem cells.

2013

Neurobiologists at the Institute of Molecular Biotechnology in Vienna coax stem cells derived from skin to assemble into chunks of brain-like tissue.

GOOD MONTH/ BAD MONTH

It's been good for: ALZHEIMER'S RESEARCH



PEOPLE SUFFERING from memory loss could be helped by stimulating their brains with magnetic pulses. Studies carried out at

Feinberg School of Medicine in the US found that Transcranial Magnetic Stimulation improved the ability of healthy adults to remember names associated with faces.

COUCH POTATOES

RESEARCHERS IN THE US have found that the desire to exercise in mice is controlled by a region of the brain called the dorsal medial habenula. The team studied mice that are genetically engineered to block signals from this area, and found they were more lethargic. It could lead to more effective treatments for depression.

It's been bad for: FANS OF JUNK FOOD



AUSTRALIAN researchers have found that junk food may reduce your desire to eat a healthy, balanced diet. They found that

rats put on a junk food diet including pies, cookies and cakes for two weeks were subsequently less likely to try new types of food. The researchers think that a diet high in junk food causes lasting changes in the reward centre of the rats’ brains.

RESIDENTS OF LOUISIANA

ANYONE FINDING THEMSELVES in Louisiana might want to stick to drinking bottled water, as the state’s water supply contains a deadly, brain-eating bacteria. Residents in St John the Baptist Parish are being advised to take precautions when using tap water after *Naegleria fowleri*, a waterborne microorganism, was found in the water supply.





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GRAPHIC SCIENCE MARS 2020 ROVER

Seeing research differently

SuperCam is an instrument to perform chemical composition analysis and search for organic compounds in rocks

Planetary Instrument for X-ray Lithochemistry (PIXL) is an X-ray fluorescence spectrometer and imager that will determine the chemical make-up of the Martian surface

Mastcam-Z is a panoramic and stereoscopic imaging camera that will investigate the Martian rock

Scanning Habitable Environments with Raman & Luminescence for Organics and Chemicals (SHERLOC) is a spectrometer that uses an ultraviolet laser to detect organic compounds

The Radar Imager for Mars Subsurface Exploration (RIMFAX) is a ground-penetrating radar that will survey the subsurface

The Mars Oxygen ISRU Experiment (MOXIE) will attempt to create oxygen from CO₂ in the Martian atmosphere

Mars Environmental Dynamics Analyzer (MEDA) will measure temperature, wind speed, pressure, humidity, and dust size and shape

SIX YEARS FROM now, NASA will be sending another robot to join Opportunity and Curiosity in exploring the Red Planet. To kit out the Mars 2020 rover, the agency has chosen seven high-tech instruments from 58 proposals

received from researchers worldwide. These instruments, detailed above, will be used to identify and select a collection of rock and soil samples that will be stored for potential return to Earth by a future mission.

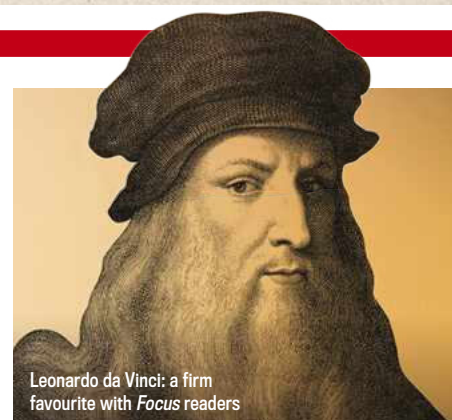
NASA administrator Charles Bolden said of the project: "Mars exploration will be this generation's legacy, and the Mars 2020 rover will be another critical step on humans' journey to the Red Planet."

POLL RESULTS

Readers crown greatest genius

FOCUS READERS HAVE named Leonardo da Vinci the greatest genius in the history of science. The Renaissance polymath pipped Albert Einstein to the post in our online poll, with the two bagging 29 and 27 per cent of the votes respectively. German mathematician Bernhard Riemann came in third with 12 per cent.

"I'm really pleased," said Sciencegrill director Heather Williams, who nominated da Vinci. "Da Vinci didn't have much of an education but he had a huge appetite for knowledge and understanding, combined with the imagination, discipline and skill to observe and test the workings of the world. He shows us what science is."



Leonardo da Vinci: a firm favourite with *Focus* readers

“Of course, if you enjoy mopping, scrubbing and vacuuming, iRobot® might not be your thing...”

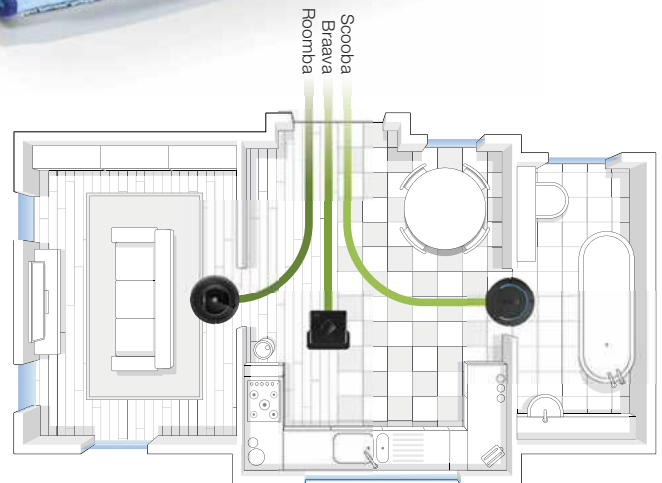


It's true. Some people actually like tedious, heavy housework. Love it, even. We don't. We do, however, love the fresh look and feel of beautifully clean floors.

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1 MINUTE EXPERT

STAMP camera



What's that? A device for taking pictures of your collection of Penny Blacks and Inverted Jennies?

Close. It's a new superfast video camera developed by engineers in Japan's Keio University. Its full name is the Sequentially Timed All-optical Mapping Photography camera.



So how fast is it?

It can record 4.4 trillion frames in a single second.

An iPhone can only manage 120.



That is fast.

Yep. So fast, in fact, that it has been used to record heat conduction, which can happen at one-sixth the speed of light.



So what can it be used for?

The camera's high frame rate will enable researchers to capture some of the most rapid processes in nature, from chemical reactions to the movement of plasma (ionised gas).



Keio University's super-quick camera

ZOOLOGY

The ears have it

New research suggests that ears play a key role in equine body language



IF YOU WANT to lead horses to water, you're going to need to pay attention to their ears. Researchers at the University of Sussex have found that horses rely on the facial features of other horses when looking for food.

"Previous work investigating communication of attention in animals has focused on cues that humans use: body orientation, head orientation and eye gaze. No one else had gone beyond that," says Jennifer Wathan of the University of Sussex. "However, we found that in horses, their ear position was also a crucial visual signal that other horses respond to."

The team printed out life-sized pictures of horses eating, placed them before one of two feeding buckets, and observed the behaviour of horses coming to feed. The horse picture faced

either to the left or the right. As expected, the horses relied on the head orientation to guide their choice. However, when the eyes and ears of the photographs were covered, the horses were less interested in the food. This suggests horses use their facial features to communicate, the researchers say.

"Most people who work alongside animals with mobile ears would agree that the ears are important in communication. We naturally have a human-centric view of the world and since we can't move our ears they get rather overlooked in other species," says Wathan. "Horses display some of the same complex and fluid social organisation that we have as humans, and that we also see in elephants, chimps and dolphins."

WHO'S IN THE NEWS?

Dr Robin Carhart-Harris

Neuropsychopharmacology researcher at Imperial College London

• What has he been up to?

Carhart-Harris is the first person in the UK to have legally administered doses of lysergic acid diethylamide (LSD) to humans since the Misuse of Drugs Act was passed in 1971.

• Why is he doing that?

It's been posited that psychedelic drugs such

as LSD and psilocybin mushrooms can help with the treatment of addiction and depression. Carhart-Harris is determining if there are any therapeutic uses for the drug.

• How might that work?

Depression and addictions are thought to create reinforced patterns of activity in the brain. Carhart-Harris

believes psychedelic drugs such as LSD may introduce some plasticity in neurones, allowing neural connections to be broken or reinforced.

• Is it safe?

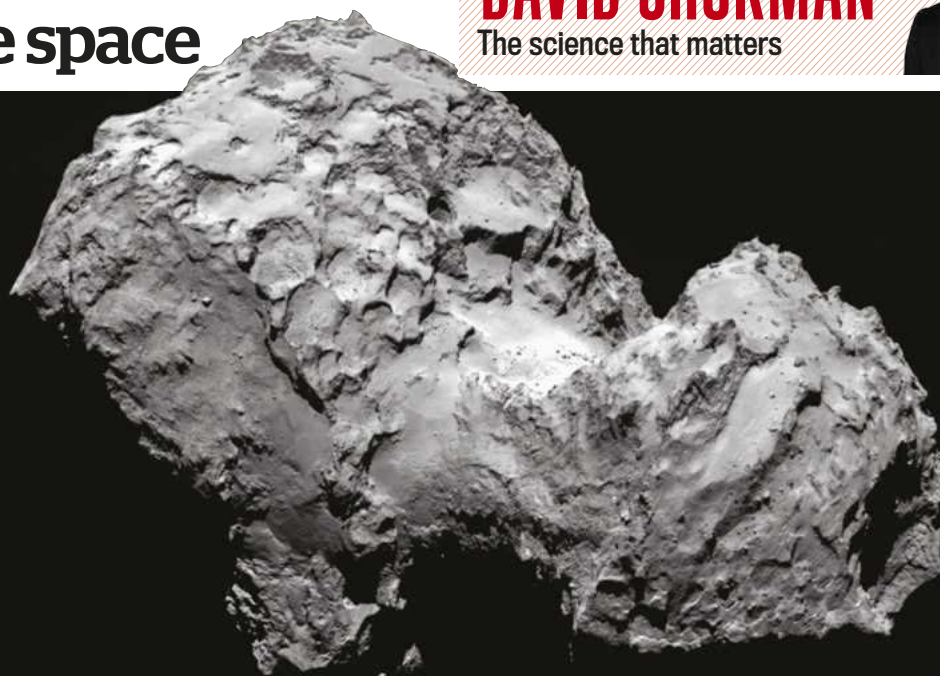
The doses involved are far lower than those typically taken by recreational users, and all of the volunteers are carefully monitored.



Why we should explore space

DAVID SHUKMAN

The science that matters



Rosetta will send a lander to comet 67P/Churyumov-Gerasimenko in November

ON THE DAY that ESA's Rosetta spacecraft achieved the incredible feat of entering into orbit around a comet, a viewer emailed to complain that the mission's billion-pound cost was simply not worth it. "What good," he asked, "might any knowledge that it might obtain do for mankind?"

Caught up in the excitement at Europe's space operations centre in Darmstadt, Germany, I was briefly lost for words. Surely, I wondered, everyone would be intrigued by clues suggesting comets brought water and carbon to the early

Earth? And how could anyone NOT want to know, I thought, if comets – with all their beauty and danger – also delivered amino acids that might have helped life get going?

In my report for *BBC News At Ten* that night, I tried to explain how these strange objects might have had a literally vital role in our planet's story. And that prompted another complaint. "Never mind the 'building blocks of life' nonsense," a fellow correspondent tweeted, "comets are just fascinating in their own right."

Of course they're fascinating – majestic and mysterious in

equal measure. But the value of discovery has always been divisive. Christopher Columbus had trouble securing funds to cross the Atlantic. The Apollo Moon landings were cut short when the American public lost interest. And consider how ridiculously little of the deep ocean has been explored.

So although curiosity is a key part of human nature, questions about the point of it will always come up whenever a bill is attached. One could argue that comets may contain precious minerals that might someday be worth exploiting – or that we need to know their structure in

case we ever have to deflect or destroy one.

I have a different answer. Previous generations, staring at comets lighting up the night sky, have only been able to feel wonder or terror. Ours is the first to have a chance of understanding these remnants of the birth of the Solar System and what they mean for us. And the price? By a very rough calculation, each European taxpayer will have chipped in about a fiver.

DAVID SHUKMAN is the BBC's Science Editor. @davidshukmanbbc

THEY DID WHAT?!

Researchers spy on each other with crisp packets

What did they do?

Scientists at MIT have created a method of turning everyday items such as crisp packets

and pot plants into makeshift microphones using high-speed video cameras.

How does that work?

Sound is a pressure wave that vibrates back and forth as it travels through the air. When it hits an object, it causes the object to vibrate. Usually, this motion is imperceptible to the naked eye, but by using a high-

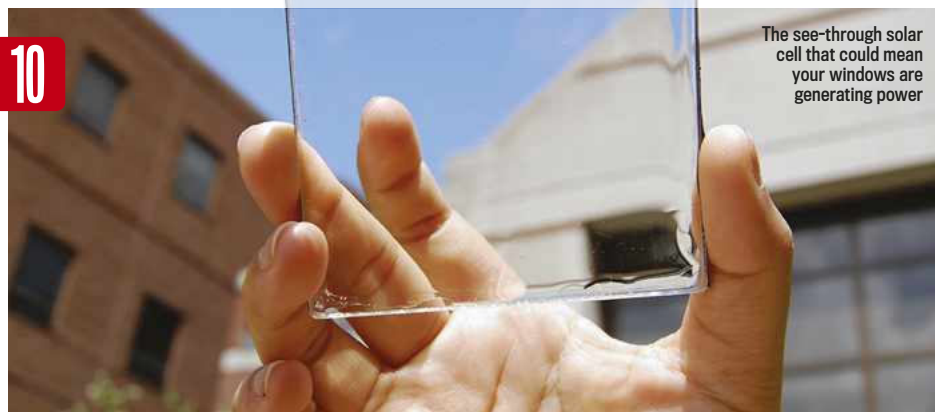


speed camera the team were able to capture the vibrations and then reconstruct the sound that caused them.

So, does this have any uses other than eavesdropping?

The team say the method could lead to a new kind of imaging that uses information about an object's vibrations to determine its acoustic properties.

10 DISCOVERIES THAT WILL SHAPE THE FUTURE



The see-through solar cell that could mean your windows are generating power

Solar cells go transparent

SOON, HOMES AND offices may be powered by their windows. A team at Michigan State University has created a transparent solar cell that could be used in buildings. It could also be used to power smartphones and other electronic devices, replacing traditional

screens. The system uses small organic molecules to absorb specific wavelengths of sunlight.

The material can be tuned to pick up just the ultraviolet and near infrared light and so appears transparent to the human eye.

9 A sight for four eyes

SAY GOODBYE TO glasses. Scientists at UC Berkeley are creating vision-correcting displays for smartphones and computers. The technology uses algorithms and a printed pinhole screen sandwiched between two layers of clear plastic to adjust the picture according to the user's vision. The displays could even help people with more complex visual problems that cannot be corrected by spectacles.



Simulated views of what a visually impaired person would see with and without a correcting display



Bacteria could be the new weapon in the fight against allergies

Gut microbes fight allergies

Food allergies could become a thing of the past thanks to a common class of gut bacteria. Researchers at the University of Chicago have found that a group of bacteria called Clostridia reduced the allergic response to peanut allergens when tested in mice. Another major group of bacteria, Bacteroides, did not have the same effect suggesting that Clostridia have a unique role against food allergens.

7 Cure jet lag with a gene

REGULAR FLYERS WHO suffer from jet lag after long-haul flights will no doubt have wished their body clock was as easy to reset as a wristwatch. Now, scientists have identified a master gene, LHX1, responsible for regulating sleep cycles. The discovery may lead to treatments to help night-shift workers or jet-lagged travellers adjust to time differences more quickly.



6 Cling film for wounds

AS ANYONE WHO has fumbled with sticking plasters and bandages will know, treating wounds in awkward areas such as fingers and toes can be frustrating. However, it is essential that the wound is kept away from bacteria while it heals. A team at Tokai University has solved this problem by creating biodegradable cling film that can keep wounds clean and protected for up to six days. The technology could be used as dressings and also for coatings on medical devices.



5 Power from perspiration

EXERCISING HAS A wealth of health benefits, but now it could also power your smartphone. A team at the American Chemical Society has created **temporary tattoos that produce power from sweat**. They use



lactate, which is present in sweat, as a power source to create a biobattery.

A powerful example of body art...

3 Cigarette butt battery

THERE ARE FEW things more useless than cigarette butts. But a team at Seoul National University has used the filters to create a material that can store energy. They transformed cellulose acetate fibres into a carbon-based material using a burning technique. **It could be used for energy storage in everything from electric vehicles to wind turbines.**



4



The green anole lizard will leave its tail behind if a predator attacks

Lizards' tail regeneration secrets revealed

A BREAKTHROUGH IN understanding how lizards regenerate their tails could lead to **new treatments for spinal chord injuries, birth defects or diseases such as arthritis**. A lizard is able to lose its tail as a defence mechanism, sacrificing it in an attempt to escape a predator. It turns out that lizards turn on at least

326 specific genes when regenerating the lost appendages. This sets in motion a process that controls stem cells in the brain, hair follicles and blood vessels.

By further studying their ability to regenerate, the researchers say they may be able to harness the same effect to treat injured humans.

2



Origami robots: hardly a threat to Optimus Prime

Robots that build themselves

MEET THE REAL-LIFE Transformers: researchers at the Massachusetts Institute of Technology have created origami-inspired autonomous robots that can assemble themselves in under four minutes.

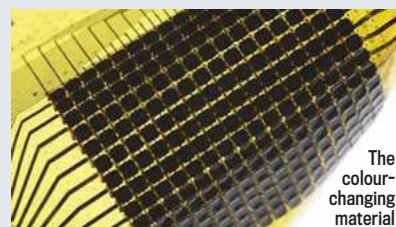
The robots consist of a sheet of paper and a polystyrene composite with hinges cut into it, a pair of motors

and a microcontroller that acts as the robot's brain. Circuits embedded in the sheet heat up, triggering the flat structure to 'fold' into a mini robot capable of walking.

The team says the technology could one day be used to create **robots capable of everything from helping with housework to repairing satellites.**

1 Invisible material

NOW YOU SEE it, now you don't. A team at the University of Houston has developed a material that can blend in with its environment. It could be used in everything from **military camouflage to wearable electronics**, its designers say. It uses light sensors, reflectors and organic colour-changing materials. The system mimics the skins of creatures like octopuses that change colour to match their surroundings.



The colour-changing material

PALAEOBIOLOGY

Fish learn how to walk on land



On land, *Polypterus senegalus* uses its fins and body to move

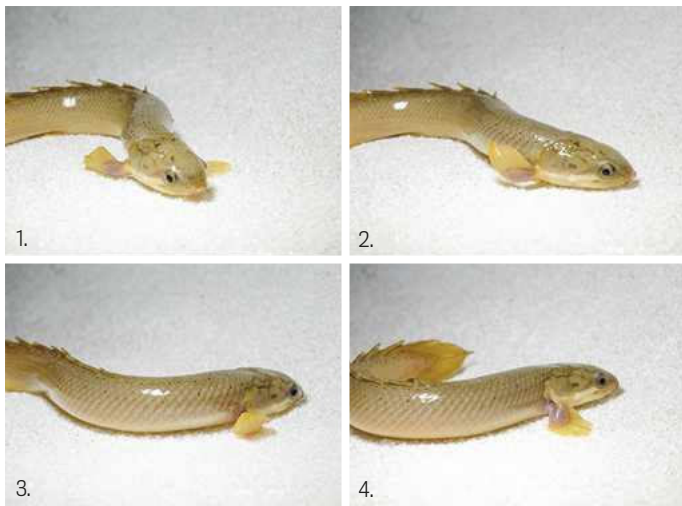
SOME 400 MILLION years ago, fish crawled out of the sea and onto land. In doing so they changed the course of life on Earth, eventually evolving into amphibians, reptiles and mammals. Now a unique experiment at Canada's McGill University has shed light on how this happened – by training fish to walk.

The experimenters took the African species bichir (*Polypterus senegalus*), which can breathe air and 'walk' using its pectoral fins. Bichir resemble the fish that evolved into tetrapods, the first four-limbed vertebrates.

"We wanted to see what new anatomies and behaviours we could trigger in these fish and see if they match what we know of the fossil record," explains project leader Emily Standen.

In the experiment, the scientists took young bichir and raised them on land, using a fine spray of mist to keep them sufficiently moist. After nearly a year, both their anatomy and behaviour had changed. Slowed-down video footage revealed how the fish were more adept at 'walking' because they kept their fins closer to their bodies. They held their heads higher, and didn't slip as much compared to fish that had been raised in water.

"Because many of the anatomical changes mirror the fossil record, the behavioural changes we see may reflect what occurred when fossil fish first walked with their fins on land," says Hans Larsson, Canada Research Chair in Macroevolution at McGill University.



Polypterus senegalus puts its best fin forward, pushing its head and body off the ground



PATENTLY OBVIOUS with James Lloyd

Inventions and discoveries that will change the world



Living labels

YOU FANCY A late night snack, but that half-finished pack of bacon in the fridge is past its best before date. Do you risk rustling up a quick bacon buttie anyway, or do you play it safe and go hungry?

It's a common dilemma, but a smart expiry label developed by a recent industrial design graduate from London's Brunel University could provide a solution. Solveiga Pakštaitė's label consists of a layer of gelatine set over a bumpy plastic sheet. At first, the gelatine is a solid jelly, but as it decays it slowly turns into a liquid, eventually allowing you to feel the bumps on the plastic beneath. Because gelatine is a protein, it decays at the same rate as protein-based foods such as meat, fish, eggs and cheese – so when you feel the bumps on the label, you know that the food is ready for the bin. By providing more accurate information than conventional labels, it's hoped that the invention will help to reduce the mountains of food and drink that are simply thrown away every year.

Patent pending

Videos with vim

AS ANYONE WHO'S ever watched someone else's holiday videos will know, amateur video recordings can be as dull as beige slacks. Thankfully, researchers at Carnegie Mellon University in the US have developed LiveLight – a system that automatically edits videos and cuts out any boring bits. Their program ignores repetitive sequences and looks for new and interesting events. So the 20 minutes of you lounging around on the beach are out; footage of you being chased by a seagull goes in.

Patent pending

Routes of beauty

Route planners like Google Maps are a handy way to explore a new city, but the quickest route often isn't the most scenic. Now, computer scientists at Yahoo Labs in Barcelona have developed an algorithm that finds the most beautiful path, taking you via attractive architecture and picturesque parks. They asked over 3,000 people online to rate the beauty of various London street scenes. The resulting trails add just a few extra minutes to the shortest route.

Patent pending

WHAT'S YOUR ANGLE?

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PSYCHOLOGY

Marching in step gives you powerful feeling

MEN FEEL MORE powerful marching in unison than when they walk in no particular formation. A study at UCLA College in California found that when men walk in step with other men, as military personnel often do, they perceive a potential enemy to be smaller and less intimidating. This has the effect of making them feel less vulnerable.

Researchers Daniel Fessler and Colin Holbrook had a theory that we've evolved to think that walking in unison signifies the strength of a group of people. To test it, they recruited male volunteers and put them in pairs. Some of the pairs marched in unison along a 250m route on the UCLA campus. Other pairs walked the same route, but not in lockstep.

Afterwards, the participants were then shown photographs of men with angry expressions on their faces and asked to judge their height. Those who had walked in unison thought the angry men were shorter and less threatening. On

Left, right, left.
Join a march to
feel powerful

average they guessed the men to be an inch shorter than those who had walked out of unison.

"Experiencing moving in unison with another person appears to make us paint a less threatening picture of a potential assailant," said lead author Fessler, a professor of anthropology in the UCLA College. "They loom less large and formidable in the mind's eye. Simply walking in sync may make men more likely to think, 'Yeah, we could take that guy!'"

The scientists believe that the behaviour could explain why riot police, who often march in lockstep, sometimes use excessive force: "We theorise that it also makes them more likely to use violence than they otherwise would be," says Fessler.



These South Korean soldiers are experiencing a collective sense of strength through marching

PHOTO: THINKSTOCK, PRESS ASSOCIATION



CLICK HERE

New websites, blogs and podcasts



TALK SPACE WEATHER

talkspaceweather.com

Since the last major geomagnetic storm in 1989, when Quebec was plunged into a nine-hour blackout, we've become much more reliant on technologies that such storms could devastate. At this site, you

can have your say about how a geomagnetic storm could affect your community and what you'd need to cope.



SONIC MELTING

soundcloud.com/sonicmelting

You've heard of glaciers melting, but have you actually heard a glacier melt? Earlier this year an anthropologist and a musician visited Quelccaya, a large glacier in the Andes. Their Sonic

Melting project includes recordings from streams and inside caves, as well as dripping water from the glacier itself.

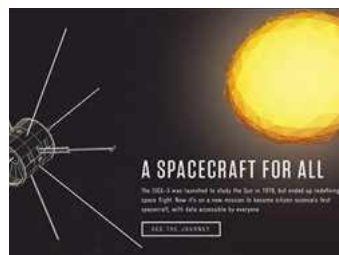


I KNOW WHERE YOUR CAT LIVES

iknowwhereyourcatlives.com

Ever posted a photo of your cat on the internet? Then take a look at this map: if you tagged your photo with a location, it could well be on there.

Made by artist, designer and programmer Owen Mundy, this site is a great – if creepy – reminder of how much data we all put out into the world.



ISEE-3

spacecraftforall.com

ISEE-3 launched in 1978 to study the Sun. A few years later it flew through a comet's tail; then NASA sent it off on a 'graveyard' orbit around the Sun. But now it's back near Earth, and has a promising future thanks to a crowdfunding effort. This Chrome experiment shows you the path taken by the spacecraft and includes interviews with scientists.



KELLY OAKES is a science journalist who tweets from @ahoakes



INSIDE SCIENCE

ROBERT MATTHEWS

Major breakthroughs can come from the most seemingly trivial of investigations

SOME OF THE world's top scientists start to get twitchy every time the phone rings at this time of the year. Will it finally be The Call From Sweden? No, not a dodgy Scandinavian chat-line ringing back, but the Royal Swedish Academy of Sciences informing them they've won a Nobel Prize.

Most scientists don't lose much sleep over getting The Call, because they know they've never made a big enough breakthrough to merit the ultimate scientific accolade. Chances are more of them fret about winning the rather less prestigious comedy version: an Ig Nobel Prize.

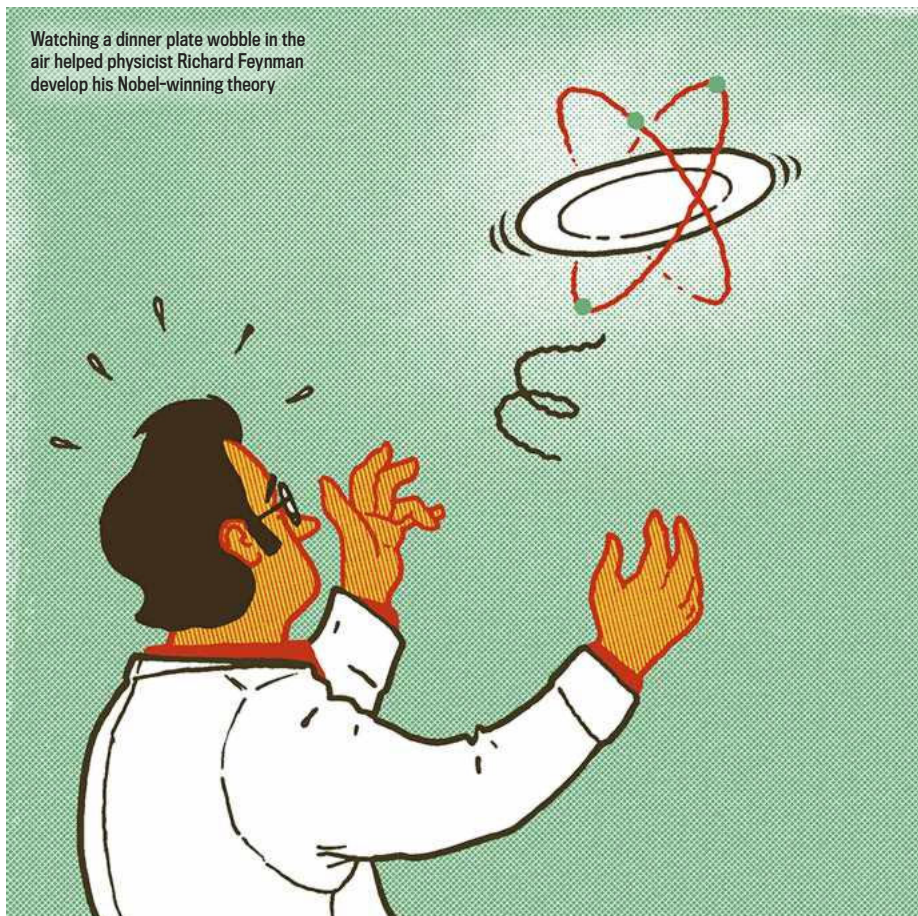
Established in 1991, each year's crop of Ig Nobels are announced just before the real thing, and often get far more media coverage. Small wonder: 'breakthroughs' honoured over the years include the discovery that dung beetles navigate using the Milky Way, that mosquitoes are attracted by the smell of Limburger cheese, and that hiccups can be stopped by sticking a finger up – well, you can probably guess where.

All these advances have been reported in respectable journals by respectable scientists. And none of them has a hope of winning a real Nobel, because they're all a bit, well, trivial. Serious breakthroughs come from research in serious fields like quantum theory, cosmology and genetics. At least, that's the general perception – but it's not always true. There are many examples of research into 'trivial' stuff that produced insights that are anything but.

In 1696, a Swiss mathematician challenged his colleagues to work out the shape into which wire must be bent so that a bead would slide from one point to another in the shortest possible time. You might think it's a straight line, but that doesn't make best use of the downward acceleration produced by gravity. The answer turns out to be a curve called a cycloid. To which the most natural response would be 'Yeah, whaddever'. But in solving the problem, the mathematician's brother came up with ideas that laid the foundation for the calculus of variations. This bag of tricks is now routinely used by physicists trying to understand everything from subatomic forces to the origin of the Universe.

It's a similar story in other areas of science. The laws of fluid flow used in climate models and aircraft design owe their origins to work on the design of a grand fountain for King Frederick the Great of Prussia.

Watching a dinner plate wobble in the air helped physicist Richard Feynman develop his Nobel-winning theory



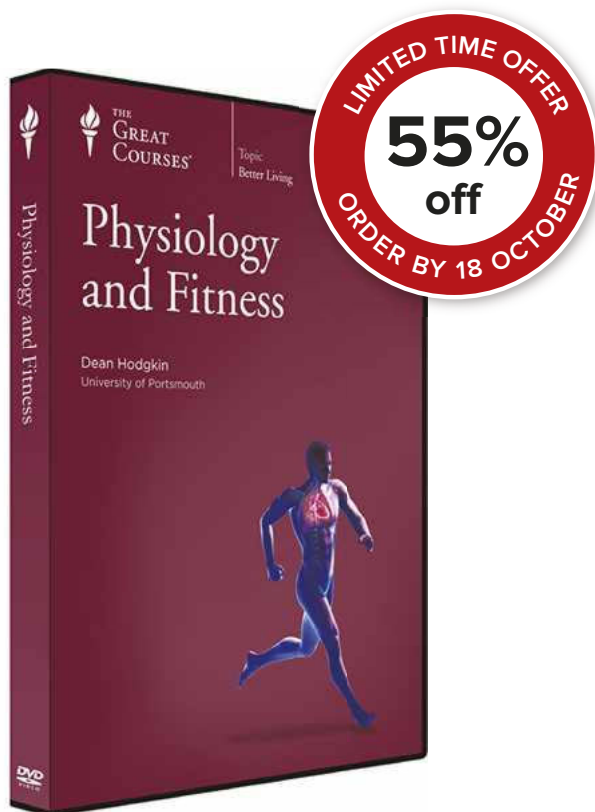
“There are many examples of research into ‘trivial’ stuff that produced insights that are anything but”

Solving a puzzle about the best route across the bridges of a Russian town led to techniques now used to understand networks in everything from electronics to ecology. The great American physicist Richard Feynman even claimed his Nobel Prize-winning work on electrons and light began by figuring out the wobble of a dinner-plate tossed in the air.

Even some Ig Nobels look capable of leading to breakthroughs. In 2011, two researchers at the University of California won an 'Ig' for studying how easily string gets knotted if carelessly handled. We all know this affects everything from headphone flex to garden hose. But it also applies to the string-like DNA crammed into our cells. Understanding how DNA stays knot-free has already led to some new therapies for disease.

I also have high hopes for the research which won an Ig Nobel in 1996, by explaining why toast so often lands butter-side down. It revealed a connection between tumbling toast and the design of the Universe which I still find amazing. But then, I would say that, as I was the author. Hey, that wasn't the phone, was it? ■

ROBERT MATTHEWS is Visiting Reader in Science at Aston University, Birmingham



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26. Medicine Ball Workout
27. Step and Interval Workout
28. Dumbbell Workout
29. Combat Workout
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EVERYDAY SCIENCE

HELEN CZERSKI

Take fat, water and add a little science to make your own butter

BUTTER PRODUCTION IS modern alchemy. Those who know the craft can convert a mundane white liquid into a deliciously rich ingot of edible gold. I've never really tried alchemy, unless you count making 'potions' when I was six, using leaves stolen from my mother's precious geraniums. But I've just tried making butter, and it's easy. All you have to do is to turn milk inside out.

It started when I put the butter back into the fridge next to a pot of cream, and wondered how much of one you needed to make the other. I didn't know, so I bought some more cream and started whisking.

Cream and milk look smooth, but that's only because their structure is too small for us to see. Both are mostly water, but the liquid is carrying passengers: proteins and fat globules that make up 5-10 per cent of the total (for milk). The fatty treasure is made up of hydrophobic molecules, which means that they are repelled by water. To keep the water at bay, the fat sits in little balloons made of proteins and other molecules. This is an emulsion, and it's as close as you can get to mixing fats or oils with water. The two types of molecules don't have to touch, because their micro-packaging keeps them apart, but every bit of water has fat globules in it.

When I started whisking, I forced all those little balloons to whoosh past each other and the whisk also pushed air down into the mixture and made bubbles. So far, so good. If a fatty balloon burst in the chaos, the fat molecules could surround an air bubble instead of mixing with the water. This is what happens when you make whipped cream – the whipping process breaks up some of the fat globules and those fat molecules surround and stabilise air bubbles. Instead of the bubbles rising through the water to the surface and being lost, they're trapped by the fat and you get lovely white foam.

It still surprises me that something as simple as vigorous mixing is enough to shift things around on a molecular scale. But after a couple of minutes, I had a bowl of whipped cream. I was just wondering whether anything else was going to happen when I noticed that a stripe of white specks was collecting on the wall, and on me. The contents of the bowl had suddenly gone lumpy and were making a serious bid for freedom.

"It still surprises me that something as simple as vigorous mixing is enough to shift things around on a molecular scale"



The fat globules had been joining together as I'd been whisking and they'd reached a magic threshold where they couldn't hold bubbles any more. The bubbles had gone, the globules had grown into lumps of butter, and the watery buttermilk was just sloshing about at the bottom of the bowl.

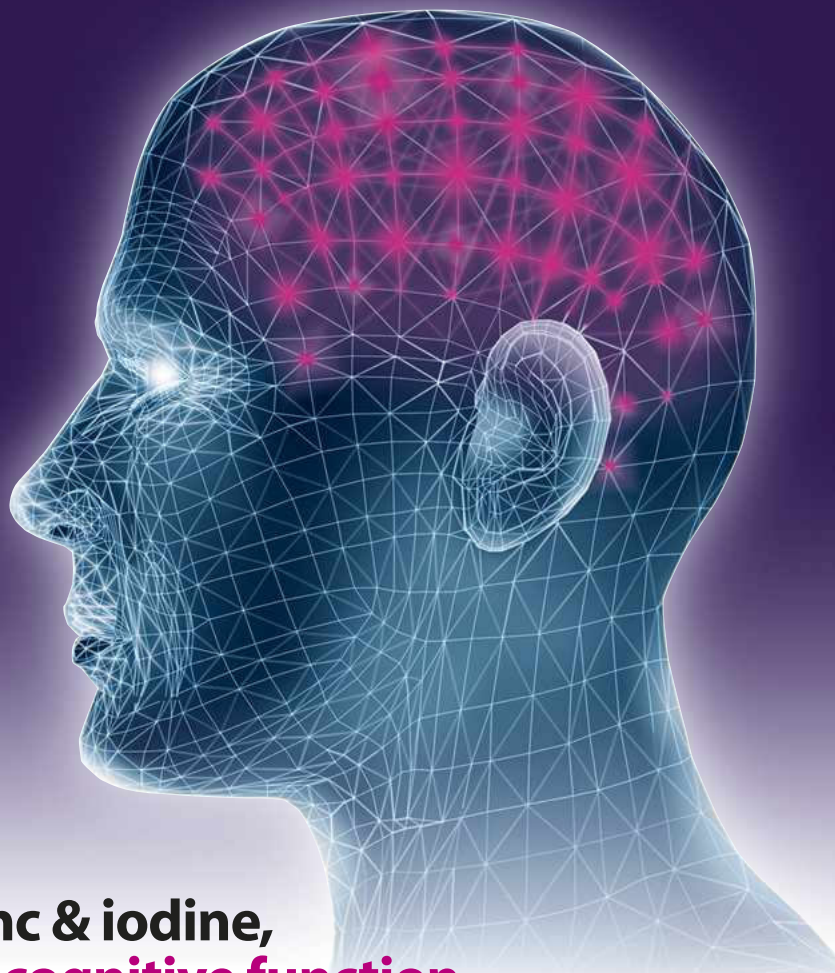
The oddest bit was washing the butter. You need to rinse the buttermilk away, so you put the butter in cold water and massage it a bit. It had never occurred to me that you could wash butter, but of course it's not going to mix with the water you're washing it with. And there you are. Two pots of cream produced about two Ping-Pong balls' worth of butter.

But I hadn't washed away all the water. Milk and cream are emulsions of fat in water, and butter is the opposite: an emulsion of water in fat. About 20 per cent of commercial butter is little globules of water that

make an important difference to the texture. The smaller they are, the smoother the butter is. Once you've turned your cream inside out, a beautiful buttery golden reward is all yours. ■

DR HELEN CZERSKI is a physicist, oceanographer and BBC science presenter whose most recent series is *Super Senses*

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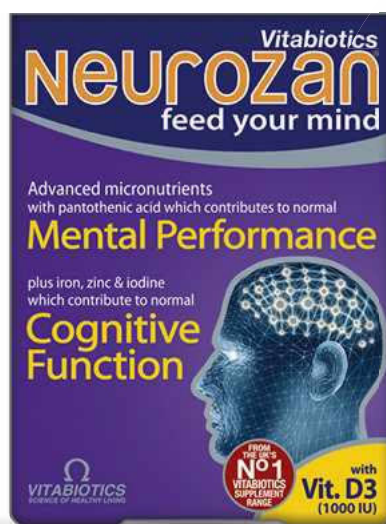
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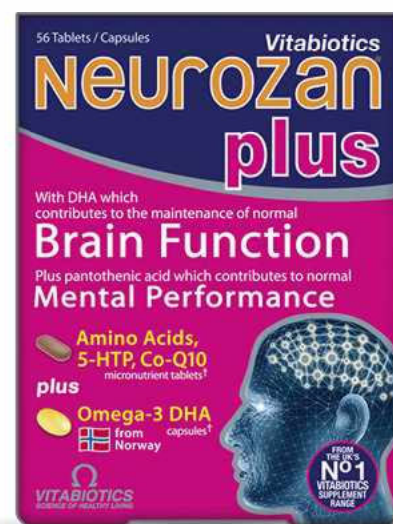
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INTO THE FUTURE

STEPHEN BAXTER

We're a nation of gardeners, but what does the future hold for the green-fingered?

OCTOBER IS AN important month for the gardener. As the hanging baskets are brought indoors and the mulch is spread on the vegetable beds, the autumn leaves are falling, and the trees are bearing a harvest of late nuts and fruit to help animals and birds survive the winter to come.

Gardening seems to be a pillar of the British identity. In World War II the memorable 'Dig for Victory' campaign turned our back gardens into a weapon to fight the Nazis. As far back as Elizabethan times, Shakespeare used the garden as a metaphor for the state of England, in *Richard II*: 'Our sea-walled garden, this whole land is fill of weeds, her fairest flowers choked up...'

But what of the future for the gardener? There are plenty of technological aids for gardening, available now or on the horizon. You can download a range of gardeners' apps, some supported by the likes of the Royal Botanic Gardens at Kew or the Royal Horticultural Society, helping you organise your seasonal chores, warning you of upcoming frosts, and planning next year's layout. One app supported by *Permaculture Magazine* is designed to help apply lessons of global sustainability to individual gardens: growing vegetables without disrupting the soil by digging, for example.

How about some practical help with those chores, though? Already there are robot lawn mowers. Here the agricultural industry is leading the way. Machines like combine harvesters have long replaced human and animal workers in the fields of the Western world.

Now organisations are developing robots capable of more delicate yet still labour-consuming tasks, such as a team at Washington State University working on an apple-picking robot. Meanwhile a Spanish start-up called Agrobot is making a machine that can pick ripe strawberries. Maybe a robot that can weed your flower beds without plucking out the prize blooms isn't far away.

Of course the venerable cultural model of the domestic garden – a scrap of land attached to an individual house – may not persist in the future, especially as more homes are built with little or no room for gardens in the first place. There are imaginative schemes to mix up urban and rural spaces, such as a plan by designer Thomas Heatherwick to create a 'floating forest' across the Thames between Temple and the South Bank in London, trees and shrubs growing from a kind of pontoon



Robots that are able to identify and pick ripe fruit are being developed

“A robot that can weed your flower beds without plucking out the prize blooms isn't far away”

bridge. The scheme has been backed by mayor Boris Johnson, among others. Or maybe our gardening will be a shared, communal effort – and this has precedents. This year is the 50th anniversary of the first 'Britain in Bloom' contest, open to all of the UK's cities and towns, which rewards a community effort to prettify your town. Or perhaps we will become tele-gardeners. That is, we will go online and work on a shared garden remotely through some kind of virtual reality interface, just as back in the 1960s the BBC's *Blue Peter* garden was established to give a taste of having a garden to children growing up in tower blocks.

Of course climate change is likely to change our gardening habits: we may find ourselves growing vines and olives rather than horse chestnuts. But if the climate modification is more extreme we may have to adapt further. Perhaps we will cultivate desert plants in the dry eastern counties,

or mangroves in the flooded lowlands of East Anglia. And maybe the last oak trees in Britain will be bonsais, grown indoors on tabletops in air-conditioned, flood-resistant houses. ■

STEPHEN BAXTER is a science fiction writer whose books include *The Science Of Avatar* and the *Northland* series



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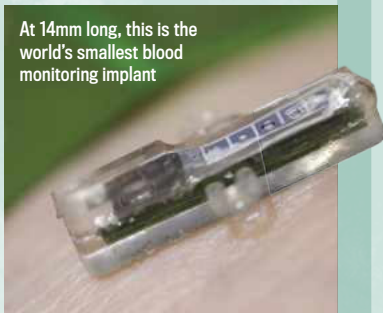
YOUR LIFE IN...

What will your everyday life be like in 40 years? Expert future-gazers paint a picture of a startling new world

DYSTOPIAN CITIES OR an urban paradise? The world will change drastically over the next 40 years; just look at how radically different life is now compared to the 1970s. To find out what the future holds, turn over for three short stories on work, rest and play, together with the science that will make them happen.

ILLUSTRATOR: ANDY POTTS

At 14mm long, this is the world's smallest blood monitoring implant



1. HEALTH MONITORING

Personal health monitors are becoming mainstream with gadgets like the Fitbit and the Jawbone. Advanced implanted versions will likely be ubiquitous for people with ongoing health conditions. A team in Switzerland is working on the world's smallest blood monitoring implant, pictured above. At just 14mm long, it tells you when you're about to have a heart attack by sending alerts to your smartphone.

3. GROW YOUR OWN

The UK only grows 60 per cent of its food, though more is exported. Rising freight costs, climate change and an increasing focus on shorter supply chains will amplify what consulting firm A.T. Kearney calls the 'locavore' trend. Increasing allotment use, kitchen-gardening and urban farms will make local, seasonal produce readily available. A company in Japan is already using LEDs to grow lettuce 24 hours a day in an indoor farm (below).



HOME SWEET HOME

PARI WAKES WITH the dawn, as always, and tells the blinds to retract. Sunlight floods into the room. She heads to the bathroom for her morning wash before the household is awake, and then to the kitchen, where she makes a cup of tea and logs in to her webdoctor.

Pari's family has a history of circulatory failure, and – while she keeps herself active and eats well – the health service likes to keep an eye out for problems before they become problems, especially in its older patients. Sometimes Pari squeezes the flesh of her left bicep just to feel the faint, hard hint of the **monitoring implant [1]** – like something sinister from the science fiction movies of her youth, she thinks, only keeping her safe. The webdoctor makes her laugh. She knows it's just an expert system and a face engine, but the skin she picked perfectly captures the professional pomposity of the big Bangladeshi man who'd been her doctor as a child. The webdoctor notices when she laughs and learns her response to elicit the same reaction.

A tap on the window announces the daily delivery of milk and eggs; it's young Daniel from a few doors down across the street, who started **rickshawing for the local grocery [2]** co-operative a few months ago. He checks off the extras Pari ordered last night on his little tablet, then relieves her of yesterday's containers, which will go back to the co-op to be cleaned and reused.

"Making something special today, Mrs. Lensing?" he asks quietly, with a broad wink. "Special event of some kind, is it?"

"Away with you, boy!" Pari giggles. "Or I'll not save you any cake."

Daniel departs to the sound of the household getting out of bed, and Pari starts preparing breakfast.

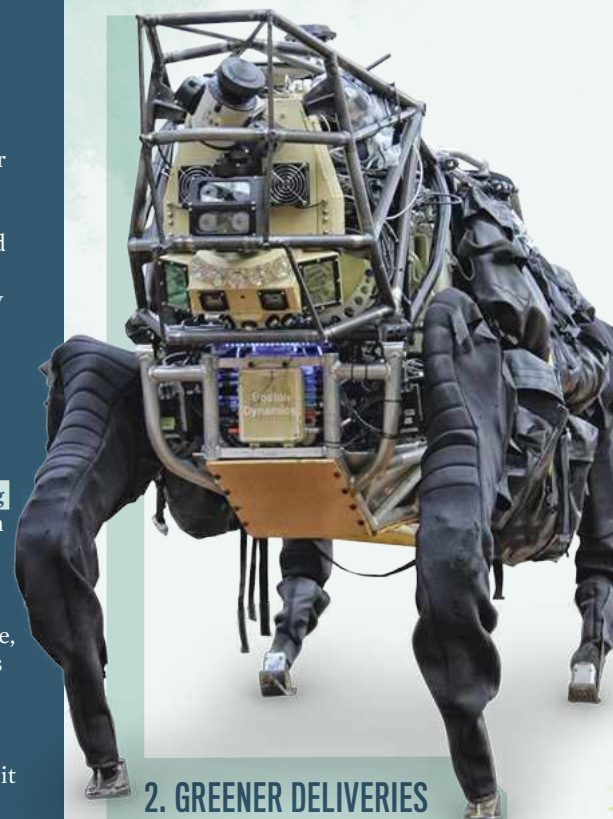
THE GOOD LIFE

By 9am, Pari has the house to herself for a few hours. Laurie has gone into the city for work, so she can meet with clients in a co-working space, while Pari's son Benedict is walking an over-excited Eira to school, despite her protests that she shouldn't have to go on her birthday. Pari goes into the little **kitchen-garden [3]** out through the back of the house. Thirty years of routine mean that she can tend the garden almost on autopilot, leaving her



BY PAUL GRAHAM RAVEN

Writer, editor of the science fiction site Futurismic.com and reviews editor of *Interzone*



2. GREENER DELIVERIES

Freight transport is not only carbon-intensive but wasteful; over three-quarters of an HGV's fuel is consumed in moving the mass of the HGV itself. The Engineering and Physical Sciences Research Council's 'All-in-One' project proposed a system of freight-delivery tunnels beneath cities that would reduce traffic and pollution. Local 'last mile' distribution and recycling collection could be done on foot, on bikes and rickshaws, or by pack-'bots like Boston Dynamics's BigDog (pictured).

"Pari squeezes the flesh of her bicep just to feel the faint, hard hint of the monitoring implant"





4. UPGRADED HOUSING

To meet emissions reduction targets, the UK will need to address the energy efficiency of its old housing stock, currently among the most wasteful in Europe. The Building Research Establishment is developing techniques for retrofitting Victorian terraced houses to meet cutting-edge efficiency standards. Thirty per cent of the UK's housing stock is terraced, making it a good target for intervention because of the lower external surface area.

6. MICRO-GENERATION

While there will still be a need for the National Grid, many ordinary homes will get much of their energy from local renewable generation, and from 'off-grid' technologies such as solar panels. Companies like eBay are already turning to radical new sources of energy, such as the Bloom Energy Server (pictured), which harnesses power from hydrogen fuel cells.

→ free to chat across the walls with the neighbours. They pass idle gossip and old anecdotes as she weeds, prunes and picks.

By elevenses, the Sun is warm on Pari's back, and the panels all along the terrace rooftops sparkle in the sunlight. She looks up from her work at the house she and her late husband bought a little over 40 years ago. Like the rest of terrace, there are changes, if you know where to look. The panels on the roof are obvious enough, but the other retrofits – **the walls skimmed and their cavities filled, the advanced window units [4]** and vents and blinds – are subtle enough that Pari sometimes forgets them. Little Eira has never known a house that wasn't smart, though. When she started speaking, Ben downloaded a personality for the house – a thing like Pira's webdoctor, but without the face. Eira now **talks to the house [5]** as if it were a member of the family. Which, Pira supposes, it might as well be.

A SMARTER HOME

Pira prefers the traditional interfaces of her youth. Kneeling among the beanstalks, she prods at her tablet. It tells her the roof panels are saturated, and the house is selling extra watts to the local grid. By being frugal in the summer – brighter and warmer than the summers of Pari's youth – they can store up energy credits against the winter, when the **heat-pump laid beneath the garden [6]** needs a bit of help.

She snaps a picture of her basket of garden peas with her tablet and sends it to the community swap-shop board. Someone agrees to her trade; 10 minutes later a young courier skids to a halt in the alleyway, sweat beading her forehead. She hands Pari a tub full of blackberries, then pedals off with the peas.

By the time Benedict arrives home, with Eira and a gaggle of her schoolmates in tow, the kitchen is full of food, including two vast cakes made with fresh blackberries. The kids have all but demolished the food by the time Laurie gets home with Eira's present: the very latest terrier form-factor **cyberdog [7]**, which Benedict has had customised so it carries the house's personality wherever it goes. As the neighbours start arriving with spare chairs and bottles of South Downs red, Eira and her friends run off into the golden light of evening to play with the newly named Wrex.

Surrounded by family and friends, Pira thinks to herself that it's not how much that's changed since her youth that's the surprising thing, but rather how little.



5. SMARTER BUILDINGS

Devices like the Nest thermostat (inset) will converge with building automation regimes such as the Passivhaus standard. It will evolve into an environmental management system that balances residential comfort with changing weather conditions, controlling the heating, windows, vents and blinds to keep things cosy or cool with the minimum of energy expenditure.



7. ROBOT PETS

While robot caregivers are unlikely to replace human ones, robot pets – whether designed to act like a 'real' animal or not – are a distinct possibility. Cleaner, easier and less carbon-intensive to look after than a live animal, robot pets could bring cat-like comfort to older people. They could also combine educational and guardian-monitor roles in a mobile kid-friendly package. Paro, a therapeutic harp seal robot, is shown below.





1. BLENDED REALITY

Virtual reality is going mainstream following Facebook's buyout of Oculus VR in March. Indeed, the BBC conducted a trial of a live 360° video broadcast to the Oculus Rift headset at this year's Glasgow Commonwealth Games. However, the big challenge is in layering the digital over the physical. Nottingham University's Mixed Reality Laboratory, for instance, is trying to better integrate telecommunications and computing into an 'augmented reality'.



WORKING
9 TO 5

THE MEETING STARTS at 10am, but Laura ducks in late. Brian sits at the far end of a gigantic slice of pine-carbon laminate, while Greg's overlit face occupies an entire wall. While Laura and the rest of her colleagues are in the Peak District office, Greg is providing advice and "a safe pair of hands" to a sibling company as they begin disassembling the first of three regional airports in the Spanish interior.

"What did I miss?" asks Laura, sliding into an articulated swivel chair.

"They're offering a second gig at a new site," explains Greg. "But it'd take me out of action through to September."

"Are you there now? Can we see?"

Greg nods, and his face disappears.

Slipping on a visor, Laura is dropped into a Spanish sky [1]. There's a brief flush of nausea as the camera drone traces a lazy arc across the site. Offering to extend their 20-80 deal on revenue from recovered materials [2], the



BY JUSTIN PICKARD

Researcher and writer with an MSc in Science and Technology Policy



2. RECYCLABLE WORLD

'Cradle-to-cradle' manufacturing is an attempt to design things that are waste-free. In essence, everything produced and consumed becomes part of a fully recyclable system. Ford embraced the idea with its Model U concept 4x4 (pictured), which features compostable body parts. In the UK, sailor Ellen MacArthur's charitable foundation is working to promote the idea, with the aim of 'accelerating the transition to a regenerative, circular economy'.

“Slipping on a visor, Laura is dropped into a Spanish sky. The camera drone traces a lazy arc across the site”



3. INTELLIGENT AGENTS

The ORCHID project, funded by the UK government, is working to understand and build what it refers to as ‘human-agent collectives’. Intelligent agents are computer programs that are given specific, pre-set goals, autonomously learning from their attempts and experiences as they go about their business. They are a spill-over from existing research on expert systems, which replicate the decision-making abilities of a human expert. Collectives integrate virtual, intelligent ‘agents’ into large-scale, decentralised teams. They could assist in everything from rapid disaster response to citizen science projects.

→ Spaniards’ projections indicate a decent price. Laura removes the visor, and runs some numbers through her scroll.

“It’s too good an opportunity to pass up,” she says. Drumming his fingers on the table, Brian disagrees, and loads up the finance visualisation. Their cash flow is a multi-hued river, rotating slowly in space. With animated particles tracing the path of rapids and eddies, it seems deeper than last month, but slows significantly at the midpoint. A vote, then, but not until they’ve seen a detailed proposal. As Greg disconnects to set a **custom agent [3]** on a 48-hour scan of likely risks, Laura spins out her own agent to dredge for insights before her afternoon meetings, then heads across to the Nag’s Head with the youngest apprentice. After a disappointing sandwich, she retreats to a toilet stall for a shot of **nasal spray [4]**. Followed by a black coffee chaser, it should leave her sufficiently amped until sundown.

Briefed by the agent’s profile of their recent projects and interests, Laura’s call with the developers returns an invitation to tender for a housing block tear-down. The conversation with Grace starts badly. Grace reminds Laura of their agreement to submit data from the structure’s manifold sensors. **“Pro-social architecture [5],”** she’d called it. In other words, subsidised rent in a brand new building in exchange for access to the firm’s feeds and their hosting a handful of apprentices. Sharpened by the nasal spray, Laura empathises, apologises, and Grace departs satisfied.

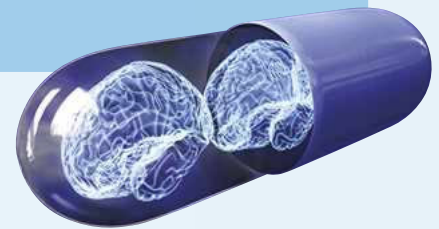
THE DAILY COMMUTE

Late leaving, Laura powers the bike across to the train station. Leaning on the motor for some of the steeper hills, she slices 10 minutes from her journey. Dropping the bike at a mushroom-shaped charging station, she just makes the train. At Manchester, she picks up one of the remaining vans. Dodging roadworks in the city centre, Laura joins a seven-vehicle convoy heading westbound on the M62, sheltering in some French lorry’s slipstream. As they pass the half-way mark, the nasal boost wears off, leaving the echo of a migraine.

Approaching Liverpool, she detaches from the convoy, cutting through the docklands and back into Hoylake. Trudging up the stairs to her third-floor apartment and collapsing into bed, the last thing she hears before passing out is the distant horn of a cargo catamaran, out on the Irish Sea.

4. SMART DRUGS

Building on existing work in personalised medicine and cognitive enhancement, Laura’s nasal spray is an example of a ‘nootropic,’ designed to boost her memory, empathy and attention. While a lot of research in this field is targeted at combating chronic disorders such as Alzheimer’s, the possibility of their wider uptake has been explored by bioethicists, such as Georgia State University’s Dr Nicole Vincent. She recently completed a Dutch-led project exploring the effects of such technology on notions of moral and legal responsibility.



5. PRO-SOCIAL ARCHITECTURE

As research on environmental psychology and architecture makes it out of the lab, businesses may find ‘pro-social architecture’ to be a cost-effective way of boosting cognition, mood, and creativity. In Austria, Prof Markus Peschl and Thomas Fundneider are conducting research into ‘enabling spaces’: workplaces that use design and technology to create innovation by encouraging openness, social interaction and creative thinking. In the UK, the Behavioural Insights Team works to apply lessons from psychology and neuroscience to the challenges of government.



HOLIDAY PLANS



1. CASHLESS SOCIETY

In use for over 7,000 years, hard currency won't disappear overnight. But with half the money we spend now paid using electronic cards, it is becoming increasingly obsolete. A cashless society has the potential to go much further. Alternative payment systems that exclude banks altogether, such as Kenya's M-Pesa, use mobile phones to let people deposit, spend, and transfer money. Or there's Coin, which can store multiple credit card details on one card (pictured). A secure digital identity allows you to access the services you are entitled to and has the potential to replace everything from car keys to ballot papers.

"It blows Julia's mind to think her grandparents would fly to a European city just for the weekend"

JULIA WAKES UP shivering in a converted shipping container somewhere in the south of London. She's been living there a week, but the container's smarhome OS isn't compatible with her phone, and the thermostat is still locked into the patterns of its previous resident. Her stomach rumbles. It's Saturday, but she knows she won't be able to get back to sleep. London is well into the late morning energy demand spike, and taking a hot shower now will cost three times the baseline rate, but Julia figures the lack of heating has more than made up the difference. As she leaves the flat, hair still damp, Julia grabs her **Authtoken [1]** – the plastic-cased chip serves as her keys, wallet and ID. A note stuck to the bedside mirror reminds her to meet Bex to make holiday plans.

The container stacks are the kind of temporary housing you can find tucked into any spare corner of the over-crowded city, as slow development struggles to meet demand. Julia's stack sits on the site of an old factory, where carbon nanotubes were once woven into useful objects. As she bangs down the metal stairs, she sends clouds of little yellow moths whirling into the morning light.

At a Turkish café on King's Avenue, Julia buys coffee and breakfast and swipes her Authtoken over the hotpress to start it printing a personalised edition of the week's news. She finds a table to spread the papers out while she sits cross-legged and pores over the latest reports. The EU is building a high-speed maglev train that will connect Lisbon to Moscow, while a crowd-funded probe has arrived at Saturn's moon Europa, where it will search for signs of life in the plumes of water jetting into space from the moon's buried oceans.

GETTING AROUND

Julia's phone pings: Bex is already in their shared living room. She should really walk – she needs to keep her pedometer metrics up, else she'll drop another health insurance bracket – but it's threatening to rain and the **autocab [2]** is already waiting at the kerb when she steps out of the café. She promises herself she'll take the stairs.

Riding up the elevator of a Clapham tower block, Julia rattles past studio after studio. Inside one, Bex is sprawled on the couch with two friends. Like most shared living rooms, the space is a mix of influences: there's a workshop loaded



BY FRANK SWAIN

Communities Editor at *New Scientist* and the author of *How To Make A Zombie*

2. AUTOCAB



Today, driverless cars are ready to hit the roads. Google's autonomous vehicles (pictured below) have already covered 482,800km (300,000 miles) without fault and most manufacturers have versions of their own robotic cars. The only roadblock to their progress is legislation. Pair their inevitable rise with the popularity of Uber (above), the app that connects people who need a ride with car owners with free time, and it's not hard to envision driverless taxis that people summon through a smart device.







3. CORNEAL DISPLAYS

Google announced earlier this year it was developing contact lenses engraved with microelectronics (pictured) that will monitor glucose levels and display warnings directly in front of diabetics' eyes. With the advance of flexible electronics, smart lenses are generating excitement, but whether they'll replace traditional screens – fundamentally unchanged for 100 years – remains to be seen.

5. HOLIDAY DESTINATIONS

Climate change is likely to spell the end of many existing holiday destinations, while opening new ones. Water shortages in arid areas such as the south of Spain will pit residents against holidaymakers, while melting ice caps will open Russia's frigid north. With escalating travel costs, maybe a more leisurely ride on a blimp will be the cruise of the future; Aeros's huge airship (pictured) is currently leading the way.



→ with tools and a 3D printer, piles of books by some weathered armchairs, turntables and a home cinema corralled by sofas. With high prices forcing multigenerational families to live under one roof, disused industrial units are increasingly rented to those looking for extra space.

The girls on the sofa are immersed in a game, co-operatively exploring the derelict environment of some procedurally generated planet, **corneal displays** [3] sparkling in their eyes. Bex cleans some mugs while Julia boils the kettle, and together they fire up travel agent apps.

EXOTIC LOCATIONS?

"Forget the Alps," Bex shakes her head. "All the slopes that have reliable snow cover are booked up years in advance, and why gamble on the others?" Julia bites her lip. Despite a host of efficiency-boosting innovations, oil prices have pushed **air travel** [4] out of the reach of casual holiday-makers. It blows Julia's mind to think her grandparents would fly to a European city just for the weekend.

"What about somewhere closer to home?" [5] Julia counters, and brings up a map of Eastbourne. The fortunes of the seaside town have been revived by the decline in foreign travel. Adventure tours offer packaged game environments that take place in the disused parts of the city. Liverpool has licensed what remains of its obsolete docklands to a continuous, live-action role-playing game themed around a Russian invasion. You can live there rent-free if you promise to stay in character.

After much discussion, the girls opt for an adventure park in Kent, the package including a three-day cruise on a hybrid airship. The huge, cumulus blimps use almost no fuel and amble in sedate loops over the Channel, offering passengers guaranteed sunshine, rarefied air, and most importantly of all, duty-free booze.

When they've made their reservations, Julia and Bex drop their mugs in the sink and head to South Kensington to see the **synthbio** [6] retrospective charting the last half century of genetically engineered species. Inside, they are overawed by full-sized taxidermies of the revived megafauna from Google's de-extinction project: towering elk, California condor, eerie Tasmanian wolves. One exhibit is given over to artificial indicator species, developed by environmentalists to locate illicitly buried industrial waste. There's something familiar about the small yellow moths pinned inside the cabinet. Julia sighs, pulls out her phone, and begins searching for new microlets to bid on. ■

Airbus's concept for a future low-emissions passenger jet



4. AIR TRAVEL

The EU wants to reduce aircraft CO₂ emissions by 75 per cent by 2050, but budget airlines and a booming Asian market are pushing up the number of flights. This goal is unlikely to be met without drastically redesigned aircraft, abandoning the tube-and-wing model for designs with morphing wings or a double-wide fuselage. Aircraft may also fly in formation to reduce drag.



6. UNNATURAL HISTORY

Synthetic biology – a toolkit for genetic engineering – is driving the development of novel organisms. The arrival of GM crops will pave the way for other creations, such as mosquitoes incapable of spreading malaria and bacteria that can both diagnose and treat disease. And what of resurrecting ancient beasts from the past? Cells have been successfully extracted from frozen woolly mammoth carcasses, so you never know.

PHOTO: GOOGLE; AIRBUS, REX; RUSS HEINL/ROYAL BRITISH COLUMBIA MUSEUM; ILLUSTRATOR: ANDY POTTS



Galloway Forest Park

home to the UK's 1st
Dark Sky Park

Black Hole discovered in Galloway

Be among the 20% of the UK's population to experience true darkness and the elite 2% that see the Milky Way. Crystal clear skies, protected Dark Skies and the Milky Way stretching from horizon to horizon.

If you want to see stars - then **Galloway Forest Dark Sky Park** is the place to come. Astrophotography shows up our immediate celestial neighbours like no other place in the UK - in proximity to cities & towns. An easy 2hrs from Glasgow and Carlisle, 4.5hrs from the midlands and you reach the astronomers dream location.

With a Bortle classification of 2 and light readings of between 21.9 – 23 it is little wonder that we see Galloway Forest not as a green wilderness but as **black wonder!**

With astronomy friendly accommodation and **Galloway Forest** Astronomical Society assistance why not come and find your ideal spot in the 300 square miles of Gold Tier darkness.

Big skies beautiful settings, quiet roads and fantastic wildlife even day time can be an enjoyable experience. Bring the family along to enjoy miles of walking trails, the world's best mountain biking on the world famous 7stanes and visit the UK's only red deer range.

"It was the most amazing sight I have ever seen" This is extraordinary and should not be missed" **"all this and it's free"** "I thought it was a cloud and it was the Milky Way" "I feel as if I could reach up and touch the stars"

"I have never been in such a dark place,
quite an experience"

Visit our website to get all the latest information and links. Come and visit us now and see why we are **The UK's 1st Dark Sky Park**

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Background
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For more information visit our website
or call us on 01671 402420
www.forestry.gov.uk/darkskygalloway

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IS STRESS GOOD FOR YOU?

Sweaty palms, a pounding heart and rapid breathing: we've all felt them. But symptoms like this may not be such a bad thing. **Lilian Anekwe** reveals the benefits of stress

Researchers used karaoke singing, public speaking and a maths exam to study the effects of stress



THINK OF THE last time you were in a stressful situation. If you felt the fear and did it anyway, was that in spite of the stress, or because of it?

We all know stress isn't good for you. We're told it's unhealthy and that we should remove it from our lives – if only it was that easy. But new research is forcing psychologists to think again. New evidence suggests that if we can learn to think about stress differently, then it can be useful, and even – believe it or not – good for us.

To be clear: persistent, unrelenting stress is bad. Ongoing stress consistently raises the levels of the hormone cortisol in our bodies, and over time this harms our health. Chronic stress can trigger headaches, musculoskeletal pain and gastrointestinal problems like irritable bowel syndrome. Stress has also been linked to depression and an increased risk of heart disease. But in the short-term, stress *could* be a power for good.

Take, for example, a recent study from the Harvard Business School, published in the *Journal of Experimental Psychology:*

General. Their researchers found that in several different stress-inducing social situations – karaoke singing, public speaking and a timed maths test – people who felt excited by the stress performed better than those who remained calm. The stress had boosted their abilities.

You might argue that this is because some people simply cope with stress better than others. But that's only part of the story, as Prof Ben Fletcher, professor of occupational and health psychology at the University of Hertfordshire, explains. "Something like a job interview is a demanding situation and as such, the body will respond. Some people will find that stressful, others energising. I think that's because most people make a negative association between stress and the strain it causes on their body."

FIGHT OR FLIGHT

When we're faced with tough situations, our bodies automatically react with a set of physiological changes known as the stress response. This arose in our ancient development as part of the 'fight or flight response', to help our ancestors deal with



Dr Jeremy Jamieson of the University of Rochester says it's not stress that's harmful – it's our attitude towards it

